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SUB-APERTURE ANTENNA MODELING ON FIXED WING AIRCRAFT

Analytic Designs, Inc.

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SUB-APERTURE ANTENNA MODELING ON FIXED WING AIRCRAFT

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13. ABSTRACT *(Maximum 200 words)*

The far field, volumetric radiation patterns for three antenna array configurations installed on a DeHavilland Dash 7 aircraft was determined. The arrays consisted of twenty-six sub-elements that were individually excited to allow arbitrary weighting for post pattern generation. The first two array configurations consisted of dipole elements offset from a ground plane. The third array configuration consisted of a slot element simulating a TEM horn antenna. All pattern data was formatted to be compatible with Air Force Research Laboratory's radar system analysis software.

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1 Introduction

The radiation performance of installed antenna arrays was desired for a De Havilland Dash-7 aircraft. Figure 1 and 2 illustrates the aircraft and the regions outlined in red where the elements of the array structure were located.

The illustration in Figure 1 shows a region in red in red where the array structure is located. This region represents a 0.7x10 meter conducting plate with its normal oriented in the y-z plane, 5° from the y-axis (towards the z-axis). The array consists of 26 subelements spaced one-half wavelength apart and a quarter wavelength from the plate. Each subarray consists of two center fed dipoles spaced one-half wavelength apart. Figure 3 illustrates the geometry of two array configurations used in these calculations. One configuration maintained the dipoles parallel to the x-y plane and is designated as the horizontal configuration. The second configuration maintained the dipoles parallel to the y-z plane and is designated as the vertical configuration.

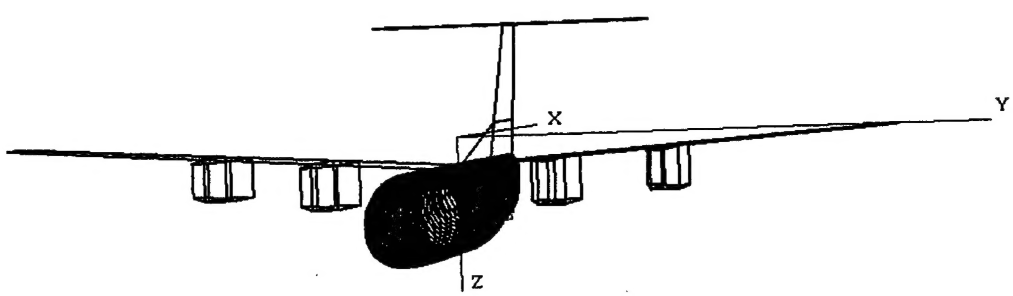

Figure 1: Illustration of Dash-7 aircraft with a 0.7x10 meter backplane for the antenna array.

The illustration in Figure 2 shows 52 regions in red where each region represents a 15" by 15" surface where a radiating element is positioned. The spacing between the center of each element region is 15.375". There are 52 regions total forming a 26x2 matrix array. Each two element column forms one subarray to yield a total of 26 subarray elements in this array. The array is positioned 12' from the nose of the aircraft to the closest subarray element edge. The center of the subarrays in the y-z plane is located 15° down from the x-y plane.

The electromagnetic analysis technique used to calculate the pattern of the subarrays installed on the aircraft was Physical Optics (PO). The pattern generation entailed the calculation of the far-field pattern for each of the 26 subarrays individually excited for later recombination with the appropriate weights. The illumination of the aircraft from the subarrays must be known for the PO solution and discussed in the following section.

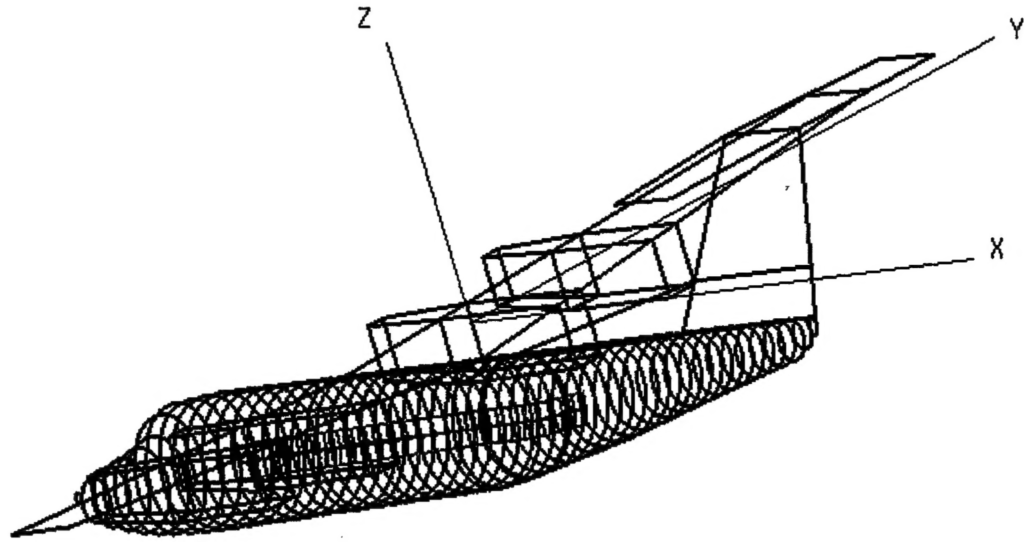

Figure 2: Illustration of Dash-7 aircraft with an antenna array.

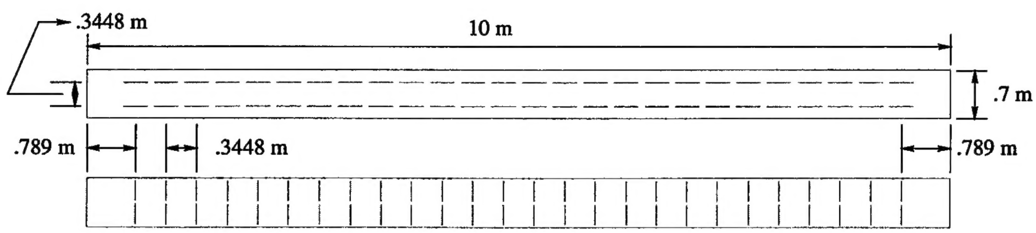

Figure 3: Illustration of the dipole spacing over backplane. Configurations: top - horizontal, bottom - vertical. Backplane shown in purple and subarray elements in red.

2 Subarray Element Synthesis

The near field patterns of the dipole and slot antennas were calculate through different means.

A variety of approaches to provide the illumination for the 26 dipole subarrays was studied in [1], and a moment method approach was chosen. The required near-field illumination was provided by a near-field calculation, consisting of integrating the surface currents for each excited and unexcited dipole pairs forming the array and the rectangular backplane. Each dipole pair (subarray element) was separated 0.3448 meters in the horizontal direction which corresponded to a half-wavelength at the operational frequency of 435 MHz and 0.1724 meters (quarter-wavelength) from the backplane. The dipoles were 0.3276 meters long (95% of a half-wavelength). Figure 3 illustrates the spacing of the dipoles over the backplane. The subarray element numbering begins with the one closest to the nose of the aircraft and proceeds

to the rear of the aircraft.

The TEM horn antenna for the third array configuration was simulated by a slot antenna. The true radiating element in this array is a TEM horn antenna with a footprint of 15" by 15" and extending 12" from the surface. Figure 4 illustrates the principle plane patterns for this antenna when configured in a 12 element array at 325 MHz. These patterns were duplicated in the deep lit region by 12 slot elements, each centered in the 15" by 15" footprint of the TEM horn antenna. The dimensions of slot elements were 0.1 by 0.3 meters. The 0.3 meter long edge of the slot was aligned with the y-z plane.

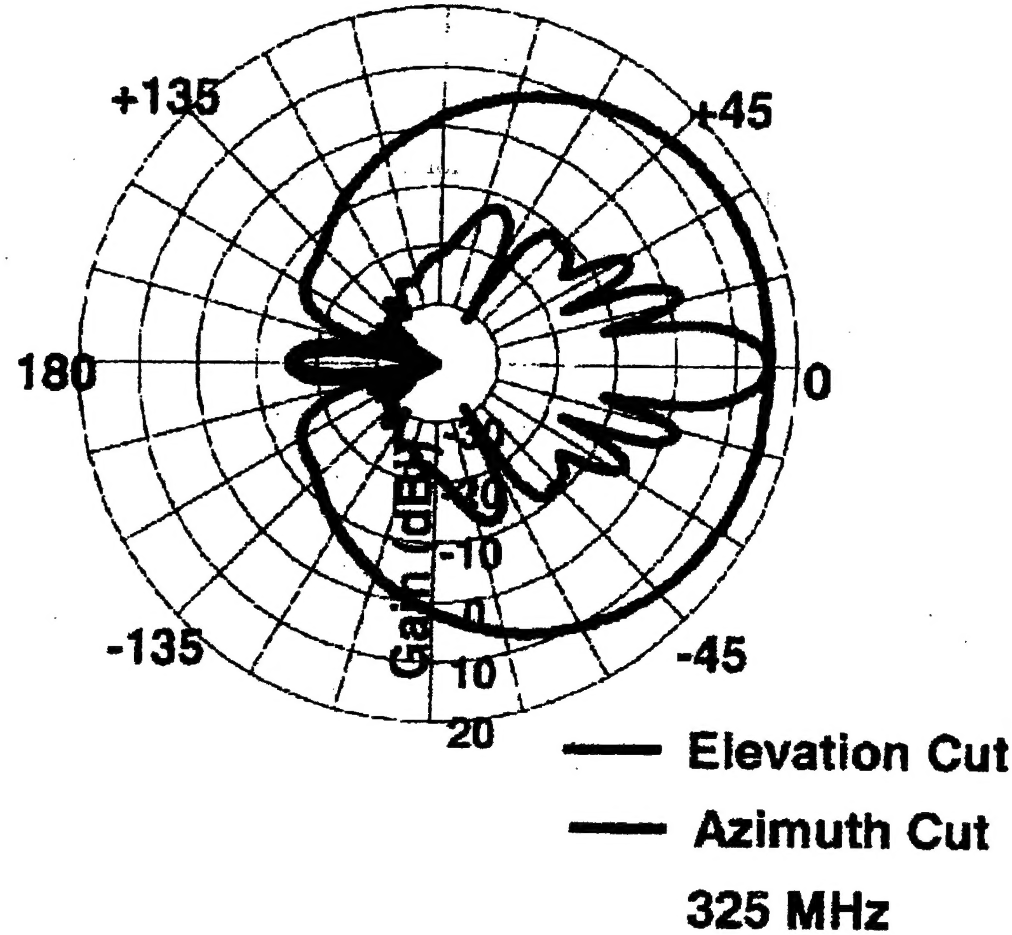

Figure 4: Illustration of the co-polarized far-field behavior for subarray element one.

3 Installed Pattern Calculation

The volumetric pattern was calculated for each individually excited subarray element using physical optics (PO) at 435 MHz. The PO approximation entailed the entire aircraft meshed into triangular facets with nodal spacings less than 0.1 wavelength. The PO current ($2\hat{n} \times \mathbf{H}^i$) was deposited on each facet and then integrated into the far-field for each radiation angle.

The output format generated consisted of a complex, copolarized gain value for each theta and phi observation angle. Theta and phi were varied every 2 degrees between $0 \leq \theta \leq 180$ and $-180 \leq \phi \leq 180$. For the horizontally polarized array configuration, the copolarized field was $\mathbf{x}$ directed and for the vertically polarized array configuration, the copolarized field was $0.0871\hat{y} + 0.9961\hat{z}$ directed. Figure 5 illustrates the far-fields for horizontally polarized dipole array element one (the one closest to the nose of the aircraft). Figure 6 illustrates the far-fields for horizontally polarized simulate TEM horn array element one (the one closest to the nose of the aircraft).

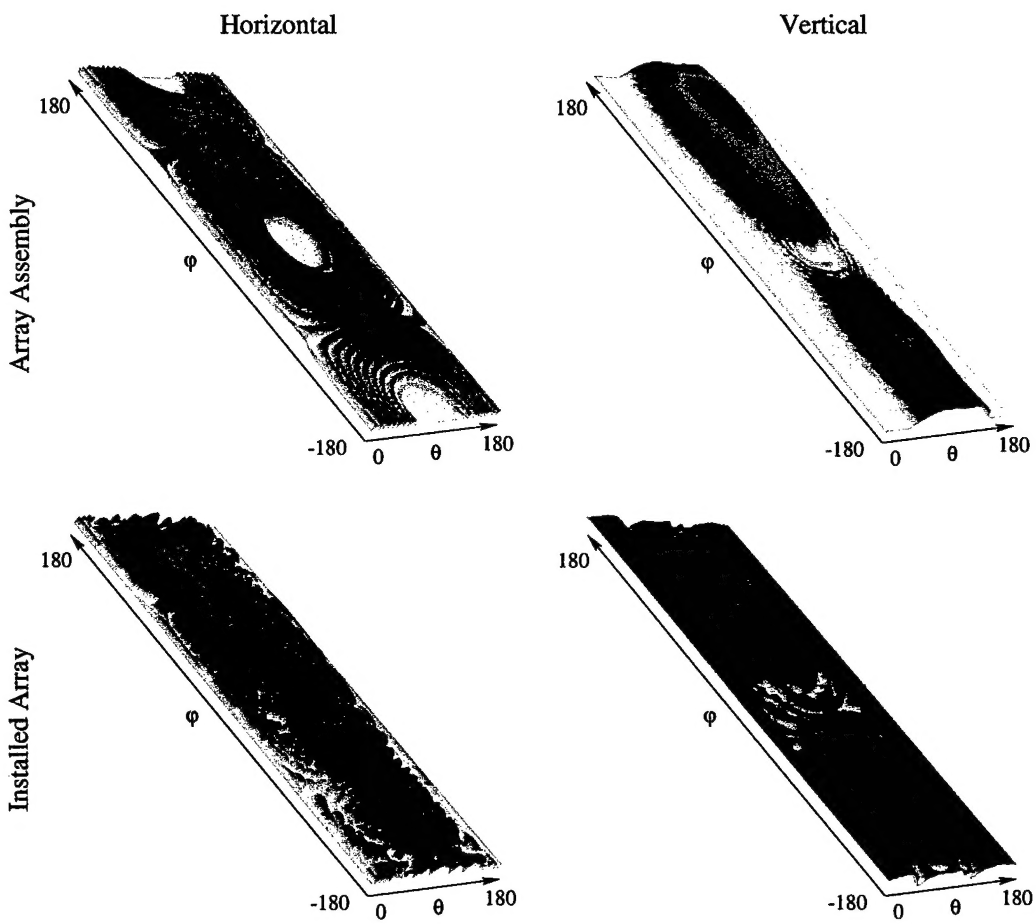

Figure 5: Illustration of the co-polarized far-field behavior for the dipole subarray element one.

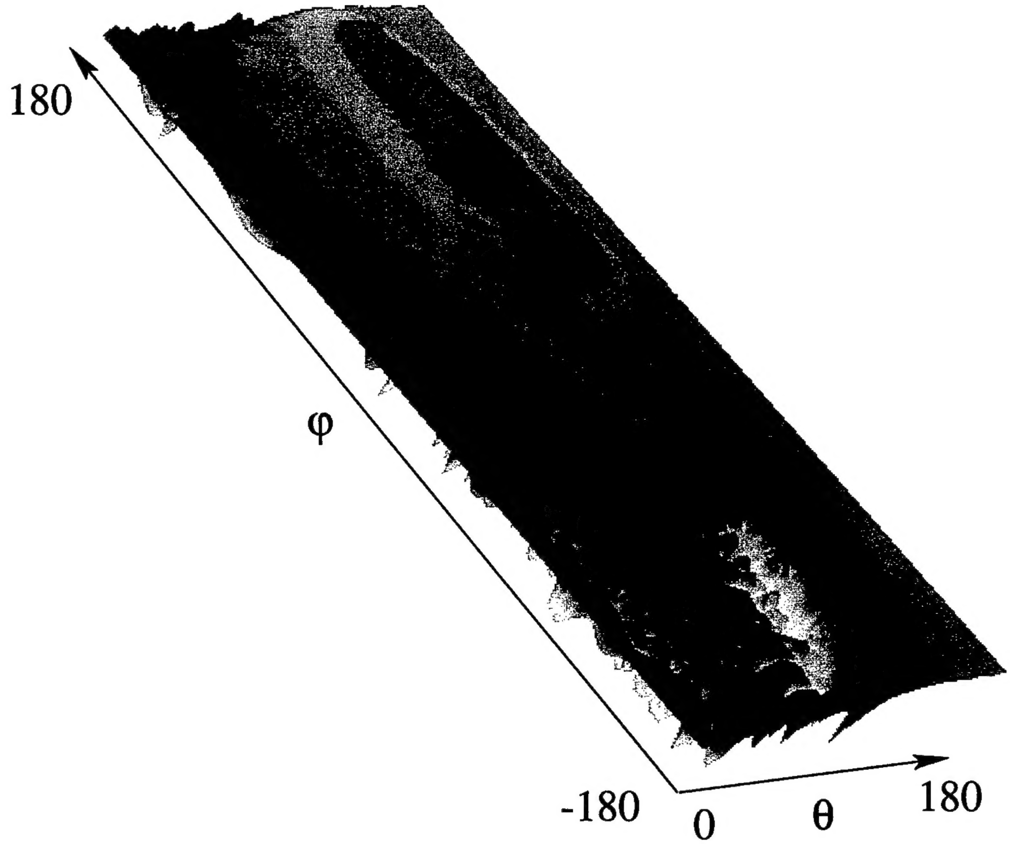

Figure 6: Illustration of the co-polarized far-field behavior for subarray element one for the TEM horn simulated element.

4 Summary

The volumetric patterns for 26 subarray elements individually excited for the described antenna configurations on a De Havilland Dash-7 were calculated. These patterns are well suited for the AFRL space-time adaptive processing code, RLSTAP.

References

[1] 'Element Synthesis for a Subarray', Analytic Designs, Incorporated, Report No. 0011-09-ROME-1, September 11, 2000.